AEP - 5
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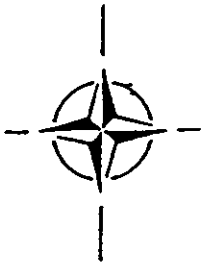

NATO INTERNATIONAL STAFF - DEFENCE SUPPORT DIVISION

ALLIED ENGINEERING PUBLICATION

NATO ARMY ARMAMENTS GROUP

NATO STANDARD ENGINE LABORATORY TEST FOR (PART I) GAS TURBINE ENGINES AND (PART II) DIESEL AND SPARK IGNITION ENGINES

MAY 1988
(Edition 3)

ALLIED
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PUBLICATION

AEP-5
(Edition 3)

AEP-5

NATO STANDARD ENGINE LABORATORY TEST FOR GAS TURBINE ENIGNES AND DIESEL AND SPARK IGNITION ENGINES

AEP-3
(Edition 3)

NATION	SPECIFIC RESERVATIONS

AEP-5
(Edition 3)

RECORD OF CHANGES

Serial No	Identification of Change and Date	By Whom Entered	Remarks

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PART I

NATO STANDARD GAS TURBINE LABORATORY TEST

AEP-5

MAY 88 ISSUE

CHAPTER 1

GENERAL - DEFINITIONS

SECTION 1-1 - GENERAL

The purpose of this document is to define a test method and standard conditions to enable all NATO countries to conduct tests using an identical method or to analyze the tests conducted in the laboratories of other NATO countries on the basis of this method.

The method described below is independent of existing national test methods, which may be used for supplementary testing.

When an engine has met the requirements of the tests under the present code, its power rating should be indicated as follow : Rated Power ... kW (... metric HP) at ... r.p.m, in accordance with NATO AEP 5 - MAY. 88 issue».

SECTION 1-2 - FIELD OF APPLICATION

These test requirements apply to gas-turbines proposed for military vehicle propulsion.

SECTION 1-3 - DEFINITIONS

A major failure is a failure of any part or component of the engine assembly that leads to a final stoppage of the engine or that brings about a loss of power which cannot be rectified to give at least 95 % of initial measured power, within the scope of normal maintenance and adjustment.

Any major failure will lead to termination of the test and any retest must start at 0 hour.

Major failures and corrective actions are to be reported to the proper National Authority.

A minor failure is a failure which leads to a loss of power or degradation of the operation of the engine and which it is possible to remedy within the scope of normal maintenance and adjustment. If 95 % of the initial measured power cannot be obtained after normal maintenance then the test will be terminated.

The minor failures and the measures taken to overcome them must be included in the report.

The suitability of an engine for NATO AEP 5 is to be the responsability of the National Authorities after completion cf the 400 hours test and consideration of the final condition of the engine.

Note : The measurement units are to be in accordance with the System International.

CHAPTER 2

TEST REQUIREMENTS

SECTION 2-1 - GENERAL COMPOSITION AND ORDER OF TEST

2.1.1. Gas turbine reception

Running-in in accordance with manufacturer's instructions.

Performance test, complete (full and part loads).

Endurance test.

Performance test, complete (full and part loads).

Disassembly, inspection and measurement.

Report.

Notes :

(1) Engine measurements may be carried out before running-in

(2) The manufacturer is responsible for defining the running-in program and the engine should have been run-in before it is submitted for testing.

(3) In so far as possible, the manufacturer's drawing and technical data will be supplied with the engine, to assist inspection and measurement of components.

(4) It is normal practice for the engine to be given a preliminary performance test immediatly after receipt, to check acceptability.

(5) If an initial inspection is accomplished, the final one should be carried out by the same inspection team using the same gauges.

2.1.2. During performance and durability testing, the following variables will be monitored :

a - Main values

Speed (engine output shaft)
Torque (engine output shaft)

b - Ambient conditions

Temperature of ambient air.
Atmospheric pressure
Humidity

c - Air and gases

Inlet air temperature
Inlet depression
Inlet air flow (performance test only)
Exhaust temperature
Exhaust back pressure
Gas temperatures at points influencing fuel control (if required).

d - Lubrication and cooling

Oil temperatures and pressures
Coolant temperatures into and out of the engine
Flow rates of fluids to cooling devices external to the engine (for heat rejection calculations). (Performance test only).
Oil consumption (during endurance tests only).

e - Fuel

Fuel temperature
Fuel consumption.

f - Miscellaneous

Smoke density
Other parameters which influence fuel control
Vibration.
Exhaust gases analysis (desirable)

2.1.3. Regulated parameters

Inlet Air Depression (*) at rated power : 25 ± 5 mbar.

Exhaust Back Pressure (**) at rated power : 40 ± 2,5 mbar.

Fuel temperature : At fuel pump inlet : 30 ± 3° C.

Inlet air temperature : The inlet temperature will be maintained as close as possible to 25° C.

(*) Depression differential between static atmospheric air pressure and the total pressure at the point of measurement.

(**) Exhaust back pressure between static atmospheric and static pressure at the point of measurement.

2.1.4. Test conditions

Measuring is to be done in normal and stable operating conditions.

The temperature of the air entering the engine (ambient air) is to be measured at a maximum distance of 0,15 m from the air filter inlet or, if there is no filter, 0,15 m from the air inlet nozzle. The thermometer or thermocouple must be protected against heat radiation and be located directly in the air jet. Testing must be carried out in an adequate number of positions to give a representative inlet temperature.

Once an output speed has been selected for measurement purposes, its value must not vary by more than ± 1 % or ± 10 r.p.m. (whichever of these limits is the higher) during measurement.

The readings for brake load, fuel consumption and inlet air temperature are to be taken simultaneously, the value recorded being the average of two stabilized results, obtained in succession with brake load and fuel consumption differing by less than 2 %.

When a device fitted with an automatic starting system is used for measuring speed and fuel consumption, the duration of measurement must be at least 30 seconds ; if the measuring device is manually operated, the duration must be at least 60 seconds.

An instantaneous consumption measuring device may be utilised.

The exhaust gas outlet temperature must be measured at a point down-stream and less than 100 mm from the flange(s) of the exhaust manifold(s).

Lubricant temperature is to be measured at the inlet and out et of the heat exchanger if there is one. Otherwise it must be taken preferably in the lubrication system. The measuring point will be specified in the test report.

Fuel temperature must be read at the fuel pump inlet.

Auxiliary power take-offs may be loaded and then measured.

2.1.5. Fuels and lubricants

Engines are to be tested on fuels and lubricants in conformity with NATO specifications or specified by National Authorities.

The references of the specifications of products used must be stated in the approval certificate.

2.1.6 Measurement accuracy

= TORQUE

The torque must be accurate within ± 0,5 % of the highest value recorded.

= OUTPUT SPEED

Measurement must be accurate to within ± 0,5 %.

= FUEL CONSUMPTION

± 1 % for all apparatus used.

= TEMPERATURES

Intake air ± 1° C.

= PRESSURE

Atmospheric pressure ± 0,7 mbar.

Air and gas pressure ± 50 mbar.

Induction and exhaust pressure and depression ± 0,250 mbar.

Pressure of other fluids ± 250 mbar.

SECTION 2-2 - DEFINITION OF ENGINE

Engines will be equipped only with such auxiliary equipment as is strictly essential to their operation.

(see table of auxiliary equipment at section 2.6).

SECTION 2-3 - PERFORMANCE TEST

The performance test maximum load curve will be plotted from measurements taken at a minimum of five speed settings, one of these settings being the rated speed.

For each setting, the engine should be run for a sufficient time to allow the operating parameters to stabilize.

Part-load data is to be recorded at the same pre-selected speeds as for the full-load test. The part loads for each speed point are to be calculated at least for 85 %, 70 %, 50 % and 25 % of the full load at the given speed.

During this test, the smoke emission as measured on the BOSCH Scale (or equivalent) shall not exceed 1.5.

In order to assess the performance data of the turbine, manufacturer's correction factors will be used.

SECTION 2-4 - ENDURANCE TEST

2.4.1. The endurance test duration is 400 hours, divided into four periods of 100 hours each. At the completion of each period, the engine shall be submitted to a full-load performance check.

2.4.2. Normal maintenance and adjustment will be permissible after each 100 hour test period.

2.4.3. Engine oil and filters may be changed after each 100 hours period.

2.4.4. The four 100 hour periods which make up the endurance test are to be carried out with the fuel and lubricant defined in 2.1.5.

2.4.5. Each 100 hour period is to comprise ten 10 hour cycles.

Each 10 hour cycle will be carried out in accordance with the program (2.5.).

The change from one running condition to another should be accomplished within 15 seconds. If not, it must be reported in the test report.

2.4.6. Data will be recorded during the last five minutes of each of the sub-cycles included in the basic 10 hour cycle, with the exception of sub-cycles 2, 4, 7, 8, 10, 11.

2.4.7. No interruptions are permitted during any of the subcycles, but the engine may be switched off on completion of any sub-cycle.

At least 5 times during each 100 hour period, the engine will be shut down for a minimum of 8 hours.

SECTION 2-5 - PROGRAM OF 10 HOUR CYCLE

Period	% Rated Speed	Load %	Duration (hours)
1	Idle (1)	Idle (1)	0,5
2	100	100 (2)	1
3	50 ——— 100 3 min 3 min	100 (2)	1
4	Stop		0,25
5	70	100 (2)	1
6	Idle	Idle	0,5
7	Idle ——— 100 2 min (3) 3 min	Idle ——— 100 (2)	2
8	Stop		0,25
9	100	100 (2)	1
10	Stop		0,25
11	Idle ——— 100 2 min (3) 3 min	Idle ——— 100 (2)	2
12	Idle	Idle	0,25
		TOTAL	10

(1)Manufacturer's published idle or as specified by vehicle installation.

(2) One hundred percent load will be governed by full throttle.

(3) The moving of the command is shorter than 3 seconds.

SECTION 2-6 - DETAILS OF REQUIRED PRODUCTION AUXILIARY EQUIPMENT

Inlet System Air Filter System Inlet Silencer	Optional
Exhaust System Piping Silencer Exhaust pipes	Test Bench Equipment
Fuel Feed Pump	Optional
Fuel Injection Equipment Prefilter Filter	Yes, or test bench equipment
Electrical Equipment	If necessary

SECTION 2-7 - INFORMATION TO BE INCLUDED IN TEST REPORT

A complete report covering all the tests, servicing, maintenance, rectification of faults and the condition of the engine at the strip examination including the measurements of the principal wearing parts will be compiled.

The report will also include the following :

1. A statement of the build standard of the engine, with drawings and a parts list.

2. Photographs of the engine from four different views.

3. Photographs of the test installation at least four different views.

4. A list of equipment fitted to the engine.

5. Sample test sheets.
   Full load performance data will be shown in the format indicated.
   A list of failures and corrective actions to overcome them.

6. An engine condition report at end of test with photographs of the condition of major parts such as combustion chamber, compressor wheels and diffusors, turbine wheels and nozzles, reduction gear and any other components of interest.

7. A history chart of lubricating oil used during the endurance tests.

8. Analysis of new and used lubricating oil, the later to be taken at approximately 100 hours intervals.

9. Fuel analysis.

10. The references of the specifications of the fuel and the lubricant used.

11. Any other relevant data.

ENGINE

LIEU PLACE

DATE

PERFORMANCES A PLEINE CHARGE
FULL LOAD PERFORMANCES

init.
fin.

REFERENCE

COMBUSTIBLE
FUEL
MASSE VOLUMIQUE (15°C)
VOLUME MASS _____ kg/dm³

HUILE
OIL
GRADE

FREIN
BRAKE type

AMBIANCE AMBIENT	t0	°C								
	p0	m bar								
PERFORMANCE	n	tr/min rpm								
	M	mdaN								
	P	kw								
COMBUSTIBLE FUEL	Cs/bsfc	g/kwh								
	q m	kg/h								
	t f	°C								
HUILE OIL	t h	°C								
	p h	bar								
ADMISSION INLET	t 1	°C								
	p0–p1	m bar								
	q a	kg/s								
ECHAPPEMENT EXHAUST	t 4'	°C								
	p4'–p0	m bar								
	fumée smoke	Bosch								

SYMBOL DEFINITIONS

ti : temperature
of
pi : pressure

air or gas i
= 0 ambient
= 1 after air filter
= 2 after compressor
= 2' after heater
= 3 after combustion chamber
= 3' after gas generator turbine
= 4 after power turbine
= 4' exhaust gas

fuel i = f

oil i = h

q : mass flow i = f fuel per hour

= a air per hour

b.s.f.c. : brake specific fuel consumption

n : rotation speed (engine output shaft)

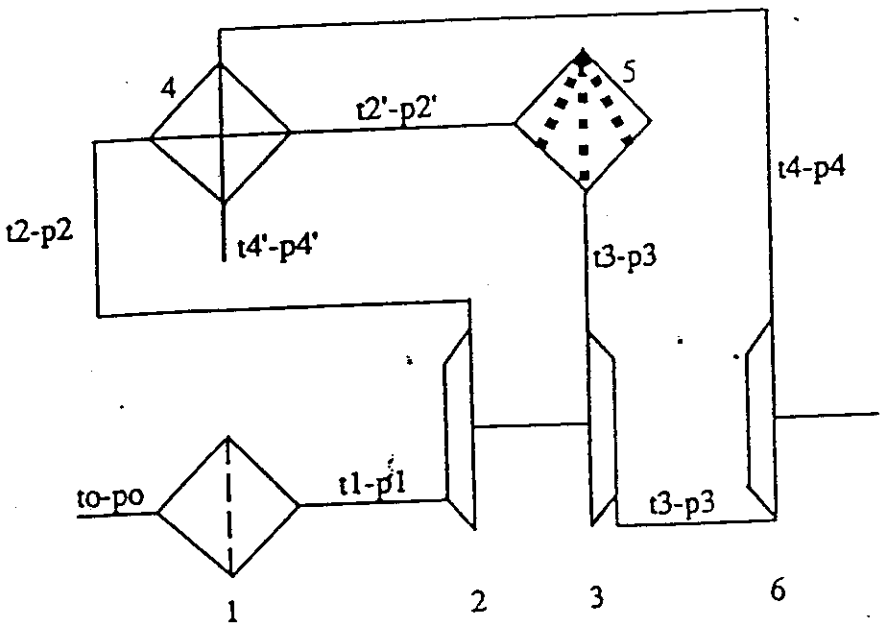
M : torque idem

P : power idem

SCHEMA DE PRINCIPE D'UNE TURBINE A GAZ

SCHEMATIC DIAGRAM GAS TURBINE ENGINE

1.	Filtre à air	-	Air filter
2.	Compresseur	-	Compressor
3.	Turbine du générateur de gaz	-	Gas generator turbine
4.	Echangeur	-	Heat exchanger
	Récupérateur	-	Recuperator or regenerator
5.	Chambre de combustion	-	Combustion chamber
6.	Turbine de puissance	-	Power turbine



NATO UNCLASSIFIED

PART II

NATO STANDARD DIESEL AND SPARK IGNITION ENGINES LABORATORY TEST

AEP-5

MAY 88 ISSUE

SECTION 1-2 - FIELD OF APPLICATION

These test requirements apply to all Diesel or Spark ignition engines proposed for military vehicle propulsion.

SECTION 1-3 - DEFINITIONS

A major failure is a failure of any part or component of the engine assembly that leads to a final stoppage of the engine or that brings about a loss of power which cannot be rectified to give at least 95 % of initial measured power, within the scope of normal maintenance and adjustment.

Any major failure will lead to termination of the test and any retest must start at 0 hour.

Major failures and corrective actions are to be reported to the proper National Authority.

A minor failure is a failure which leads to a loss of power or degradation of the operation of the engine and which it is possible to remedy within the scope of normal maintenance and adjustment. If 95 % of the initial measured power cannot be obtained after normal maintenance then the test will be terminated.

The minor failures and the measures taken to overcome them must be included in the report.

The suitability of an engine for NATO AEP 5 is to be the responsability of the National Authorities after completion of the 400 hours test and consideration of the final condition of the engine.

Note : The measurement units must be in accordance with the System International.

CHAPTER 2

TEST REQUIREMENTS

SECTION 2-1 - GENERAL COMPOSITION AND ORDER OF TEST

2.1.1. Engine reception

Running-in in accordance with manufacturer's instructions.
Performance test, complete (full and part loads).
Endurance test.
Performance test, complete (full and part loads).
Disassembly, inspection and measurement.
Report.

Notes :

(1) Engine measurements may be carried out before running-in

(2) The manufacturer is responsible for defining the running-in program and the engine should have been run-in before it is submitted for testing.

(3) In so far as possible, the manufacturer's drawing and technical data will be supplied with the engine, to assist inspection and measurement of components.

(4) It is normal practice for the engine to be given a preliminary performance test immediatly after receipt, to check acceptability.

(5) If an initial inspection is accomplished, the final one should be carried out by the same inspection team using the same gauges.

2.1.2. During performance and durability testing, the following variables will be monitored :

a - Main values

Speed (engine output shaft)
Torque (engine output shaft)

b - Ambient conditions

Temperature of ambient air.
Atmospheric pressure
Humidity

c - Air and gases

Inlet air temperature
Inlet or cylinder inlet depression
Inlet air flow (performance test only)
Air temperature and pressure in the inlet manifold
Exhaust temperature
Exhaust back pressure

d - Lubrication and cooling

Oil temperatures and pressures
Coolant temperatures into and out of the engine
Flow rates of fluids to cooling devices external to the engine (for heat rejection calculations). (Performance test only).
Oil consumption (during endurance tests only).

e - Fuel

Fuel temperature
Fuel consumption.

f - Miscellaneous

Blow-by
Smoke density.
Exhaust gases analysis (desirable)

2.1.3. Regulated parameters

Outlet temperature of cooling agent
a - water + antifreeze = 96° C ± 3° C
b - other cooling agents = to manufacturers specifications

Inlet Air Depression (*) at rated power : 25 ± 5 mbar
Exhaust Back Pressure (**) at rated power : 40 ± 5 mbar

Fuel temperature : At injection pump inlet : 30 ± 3° C

Inlet air temperature : The inlet temperature will be maintained as close as possible to 25° C.

(*) Depression between static atmosphere and total pressure at the point of measurement.

(**) Exhaust back pressure between static atmospheric and static pressure at the point of measurement. For small engines, which are sensitive to exhaust back pressure manufacturers' recommended figures should be used.

2.1.4. Test conditions

Measuring is to be done in normal and stable operating conditions.

The temperature of the air entering the engine (ambient air) is to be measured at a maximum distance of 0,15 m from the air filter inlet or, if there is no filter, 0,15 m from the air inlet nozzle. The thermometer or thermocouple must be protected against heat radiation and be located directly in the air jet. Testing must be carried out in an adequate number of positions to give a representative inlet temperature.

Once an output speed has been selected for measurement purposes, its value must not vary by more than ± 1 % or ± 10 r.p.m. (whichever of these limits is the higher) during measurement.

The readings for brake load, fuel consumption and inlet air temperature are to be taken simultaneously, the value recorded being the average of two stabilized results, obtained in succession with brake load and fuel consumption differing by less than 2 %.

When a device fitted with an automatic starting system is used for measuring speed and fuel consumption, the duration of measurement must be at least 30 seconds ; if the measuring device is manually operated, the duration must be at least 60 seconds.

An instantaneous consumption measuring device may be utilised.

The exhaust gas outlet temperature must be measured at a point downstream and less than 100 mm from the flange(s) of the exhaust manifold(s).

Lubricant temperature is to be measured at the inlet and outlet of the heat exchanger if there is one. Otherwise it must be taken preferably in the lubrication system, or, failing this, in the sump. The measuring point will be specified in the test report.

Fuel temperature must be read at the injection pump inlet, or carburettor inlet.

Auxiliary power take-offs may be loaded and then measured.

2.1.5. Fuels - lubricants and anti-freezes

Engines are to be tested on fuels, lubricants and anti-freezes in conformity with NATO specifications or specified by National Authorities.

The references of the specifications of products used must be stated in the approval certificate.

2.1.6. Measurement accuracy

= TORQUE

The torque must be accurate within ± 0,5 % of the highest value to be measured.

= OUTPUT SPEED

Measurement must be accurate to within ± 0,5 %.

= FUEL CONSUMPTION

± 1 % for all apparatus used.

= TEMPERATURE

Intake air ± 1° C.

= PRESSURE

Atmospheric pressure ± 0,7 mbar.

Air and gas pressure ± 50 mbar.

Induction and exhaust pressure and depression ± 0,250 mbar

Pressure of other fluids ± 250 mbar.

SECTION 2-2 - DEFINITION OF ENGINE

Engines will be equipped only with such auxiliary equipment as is strictly essential to their operation (see table of auxiliary equipment at section 2.6.)

SECTION 2-3 - PERFORMANCE TEST

The performance test maximum load curve will be plotted from measurements taken at a minimum of five speed settings, one of these settings being the rated speed.

For each setting, the engine should be run for a sufficient time to allow the operating parameters to stabilize.

Part-load data is to be recorded at the same pre-selected speeds as was used for the full-load test. The part loads for each speed point are to be calculated at least for 85 %, 70 %, 50 % and 25 % of the full load at the given speed.

During this test, the smoke emission as measured on the BOSCH Scale (or equivalent) shall not exceed 4.5. (Diesel engines only).

No correction factor will be applied and the test results must include air temperature, atmospheric pressure, and hygrometry.

SECTION 2-4 - ENDURANCE TEST

2.4.1. The endurance test duration is 400 hours, divided into four periods of 100 hours each. At the completion of each period, the engine shall be submitted to a full-load performance check.

2.4.2. Normal maintenance and adjustment will be permissible after each 100 hour test period.

Engine oil and filters may be changed after each 100 hour period.

2.4.3. The engine oil temperature is to be measured in the lubrication system. The temperature measurement location shall be specified.

2.4.4. The four 100 hour periods which make up the endurance test are to be carried out with the fuel and lubricant defined in 2.1.5.

2.4.5. Each 100 hour period is to comprise ten 10 hour cycles.

Each 10 hour cycle will be carried out in accordance with the program (2.5.).

The change from one running condition to another should be accomplished within 15 seconds. If not, it must be reported in the test report.

2.4.6. Data will be recorded during the last five minutes of the sub-cycles included in the basic 10 hour cycle, with the exception of sub-cycles 5.

2.4.7. No interruptions are permitted during any of the subcycles,but the engine may be switched off on completion of any sub-cycle.

At least 5 times during each 100 hour period, the engine will be shut down for a minimum of 8 hours.

hour prior to resumption of test

SECTION 2-5 - PROGRAM OF 10 HOUR CYCLE

Sub-cycle	% Rated Speed	% Load	Duration in hours
1	IDLE (1)	0	1/2
2	100	100 (5)	2
3	governed speed (2)	0	1/2
4	75	100 (5)	1
5	Idle (1)_____100 (3)	0 _____100 4 min 6 min	2
6	60	100 (5)	1/2
7	IDLE (1)	0	1/2
8	governed speed (4)	70 (6)	1/2
9	Max torque speed	100 (5)	2
10	60	50 (6)	1/2
TOTAL			10

Notes :

(1) Deviation from the regulated outlet coolant temperature (96° C+ 3° C) is permitted

(2) The speed shall be that obtained with the engine at full throttle and with minimum load (residual brake load).

When the engine is not fitted with a governor, the throttle will be adjusted to obtain 110 % of the rated speed.

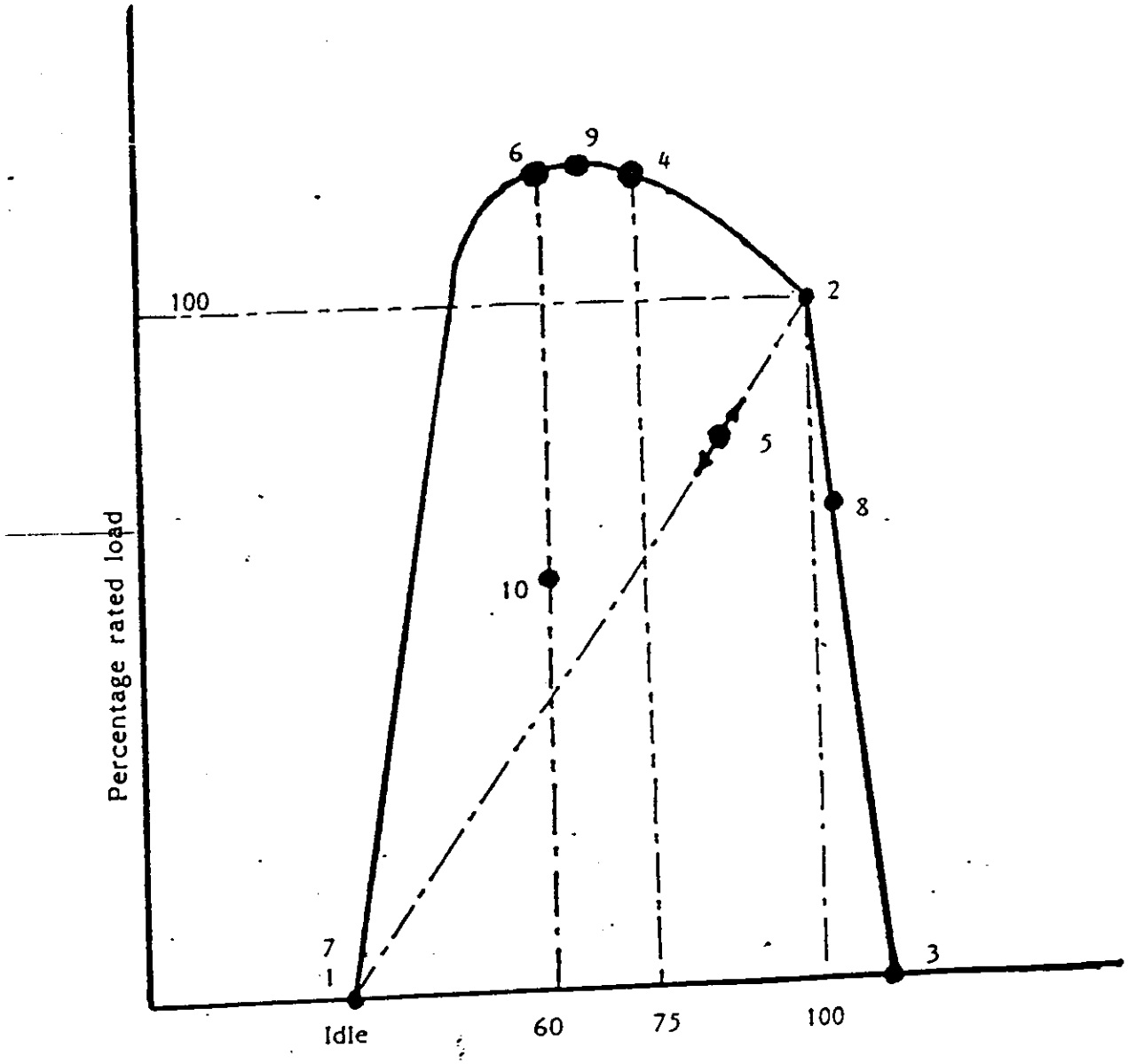
(3) The moving of the command is shorter than 3 seconds.

(4) The speed shall be the steady speed of the engine at full throttle and 70 % load.

When the engine is not fitted with a governor the speed will be 103 % of the rated speed.

(5) One hundred percent load will be governed by full throttle.

(6) Part loads (70 and 50 %) shall be taken from the initial performance test.



PERCENTAGE SPEED
GRAPHICAL PRESENTATION OF 10 HOUR CYCLE

SECTION 2-6 - DETAILS OF REQUIRED PRODUCTION AUXILIARY EQUIPMENT

Inlet system Inlet manifold ..... Air filter ..... Inlet silencer ..... Blowby gas recirculation intake	Yes Optional
Exhaust system Manifold ..... Piping ..... Silencer ..... Exhaust pipes	Yes Test bench equipment
Fuel feed pump	Yes
Carburettor	Yes (details of adjustment will be specified)
Ignition system Distributor ..... Spark-plugs ..... Coils ..... Suppressor	 Yes Yes Yes Yes
Fuel injection equipment Prefilter ..... Filter ..... Pump ..... High-pressure pipes ..... Injector ..... Regulator	 Yes or test bench equipment Yes Yes Yes Yes

Liquid cooling equipment	
Radiator	No
Fan	Yes
Water pump	Yes
Thermostat	
Air cooling equipment	
Streamlining	Yes
Blower	Yes
Temperature regulating device	Yes
Electrical equipment	If necessary
Supercharging equipement	
Compressor driven directly or indirectly by the engine and/or exhaust gas	Yes
Charge cooler	Yes
Cooling pump or fan (engine driven)	Yes
Device for regulating flow of cooling fluid	Yes

SECTION 2-7 - INFORMATION TO BE INCLUDED IN TEST REPORT

A complete report covering all the tests, servicing, maintenance, rectification of faults and the condition of the engine at the strip examination including the measurements of the principal wearing parts will be compiled.

The report will also include the following :

1. A statement of the build standard of the engine, with drawings and a parts list.
2. Photographs of the engine from four different views.
3. Photographs of the test installation at least four different views.
4. A list of equipment fitted to the engine.
5. Sample test sheets.
   Full load performance data will be shown in the format indicated.
   A list of failures and corrective actions to overcome them.
6. An engine condition report at end of test with photographs of the condition of major parts such as pistons, bearings, valves, camshafts, crankshafts, cylinder bores together with any other components of interest.
7. A trend chart of oil consumption and blow-by during the endurance tests.
8. Analysis of new and used lubricating oil, the later to be taken at approximately 100 hours intervals.
9. Fuel analysis.
10. The references of the specifications of the fuel, the lubricant and the anti freeze used.
11. Any other relevant data.

PERFORMANCES A PLEINE CHARGE — init.
FULL - LOAD PERFORMANCES — fin.

REFERENCE _____

COMBUSTIBLE _____
FUEL
MASSE VOLUMIQUE (15°C)
VOLUME MASS _____ kg/dm³

HUILE _____
OIL
GRADE

FREIN type _____
BRAKE

AMBIANCE AMBIENT	t0	°C								
	p0	m bar								
PERFORMANCE	n	tr/min r.p.m								
	M	mdan								
	P	kw								
	p.m.e m.e.p	bar								
COMBUSTIBLE FUEL	Cs/bsfc	g/kwh								
	Qc	mm/c								
	qm	kg/h								
	tf	°C								
HUILE OIL	th	°C								
	ph	bar								
EAU WATER	te	°C								
	ts	°C								
ADMISSION INLET	t1	°C								
	p0–p1	m bar								
	t2	°C								
	p2	bar								
	t2'	°C								
	p2–p2'	m bar								
	qa	kg/s								
ECHAPPEMENT EXHAUST	t3	°C								
	p3	bar								
	t4	°C								
	p4–p0	m bar								
	fumée smoke	Bosch								
souflage carter Blow by		l/mn								

SYMBOL DEFINITIONS

ti : temperature
of
pi : pressure

air or gas i = 0 ambient
= 1 after air filter
= 2 after compressor
= 2' after charge cooler
= 3 at turbine inlet
= 4 after turbine

fuel i = f

oil i = h

water i = e inlet engine
= s outlet engine

q : mass flow i = f fuel per hour
= a air per hour

qc : volumetric flow injected per cycle and per cylinder

bsfc : brake specific fuel consumption

bmep : brake mean effective pressure

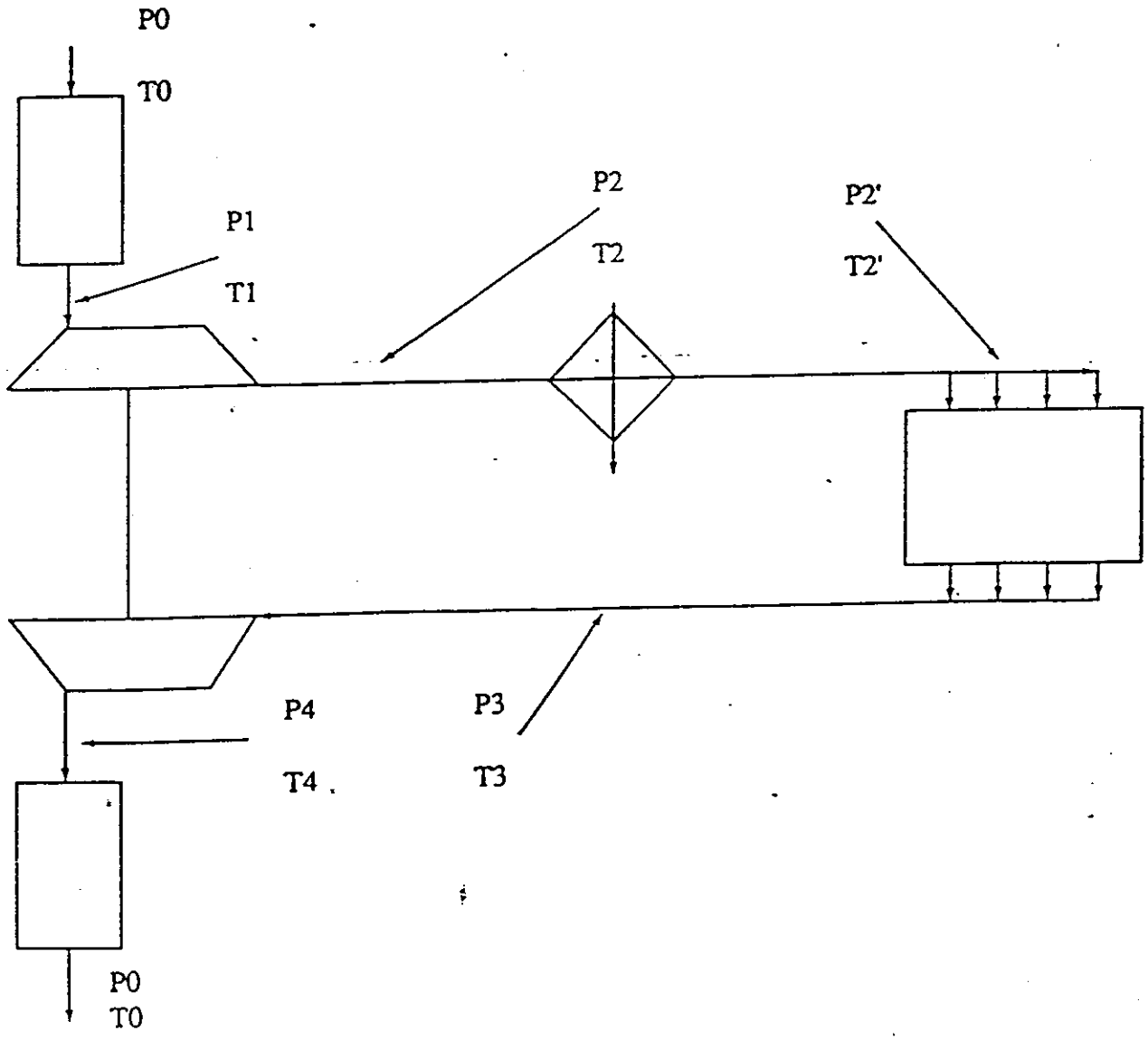
n : rotation speed (engine output shaft)

M : torque idem

P : power idem

SCHEMA DE PRINCIPE DE MOTEUR DIESEL ET A ALLUMAGE COMMANDE

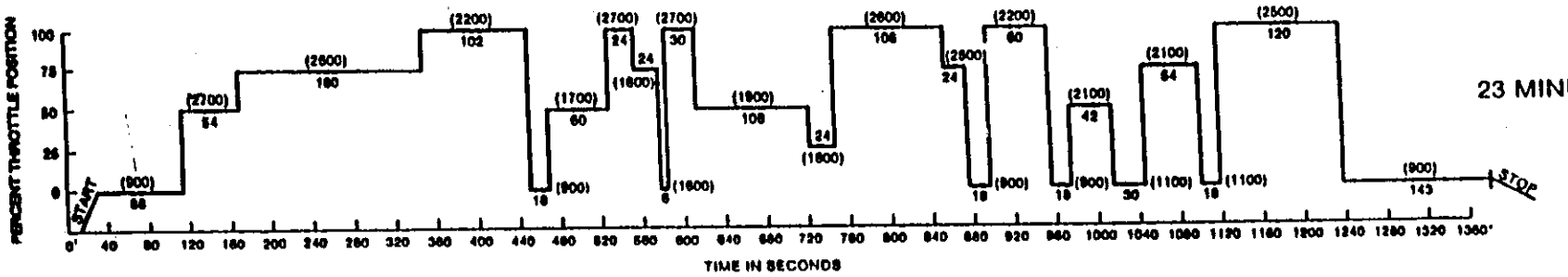
SCHEMATIC DIAGRAM DIESEL AND SPARK IGNITION ENGINE



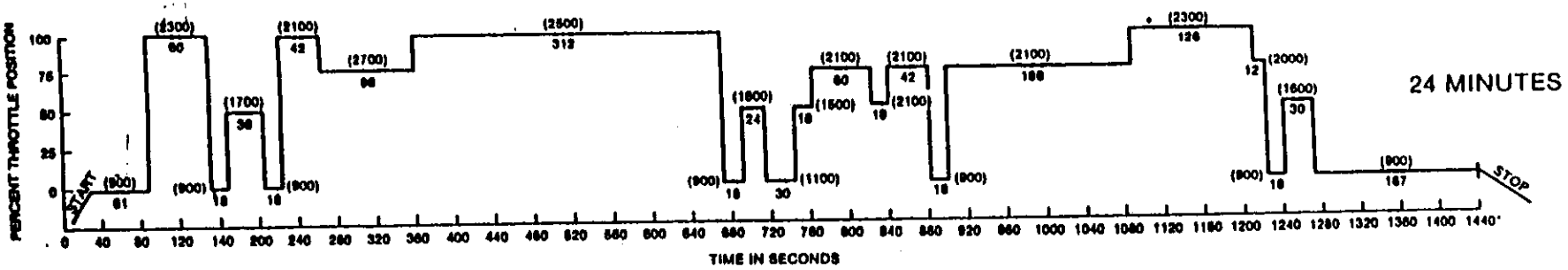
600-HOUR MISSION PROFILE TEST

(NUMBERS IN PARENTHESES ARE OUTPUT SHAFT SPEEDS)

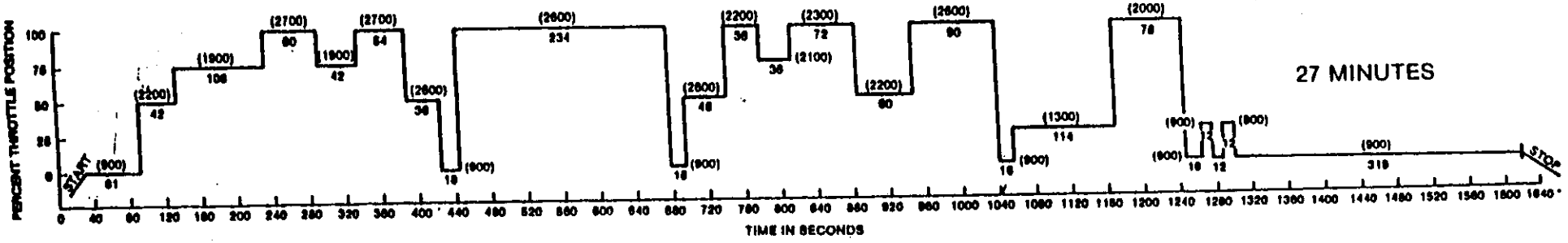
*3 MINUTE WAIT BEFORE NEXT START



23 MINUTES



24 MINUTES



27 MINUTES

TOTAL CYCLE 74 MINUTE CYCLE FOR 487 CYCLES